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1st AIAA CFD Transition Modeling and Prediction Workshop

Case 4 – CRM-NLF – alpha sweep

Greg Delattre

Outline

- Solver & models
- Grids
- Pressure coefficient, transition lines
- Force and moment data
- Perspectives

Outline

- **Solver & models**
- Grids
- Pressure coefficient, transition lines
- Force and moment data
- Perspectives

Solver & models

- elsA CFD solver © Airbus-Safran-Onera
- RANS FV on structured grids, 2nd order Roe scheme
- Menter SST turbulence model (SST-V on TMR)
- Transported AHD-GL transition model
  - Focusing on wing suction side
  - Transition is imposed
    - @ 5% x/c on wing pressure side
    - @ trip dots locations on fuselage nose

Stability-Based Transition Model using Transport Equations

https://doi.org/10.2514/1.J058906

- Combination of two transition criteria on Re_θ:
  - AHD → streamwise natural transition
  - Gleyzes → separation-induced transition
- 4-equation model:
  - Transport critical value of $Re_{\theta,cr}$
  - Integration/averaging of the Pohlhausen parameter Λ_2 following streamlines at BL edge
  - 2 x Integration of the curvilinear coordinate:
    - One for Λ_2 averaging
    - One for intermittency raising in the transition region

Stability-Based Transition Model using Transport Equations

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- Combination of two criteria on Re_θ:
  - AHD derived for streamwise natural transition $Re_{\theta,tr} = fn(Me, Tu, \overline{\Lambda}_2, Re_{\theta,cr})$
  - Gleyzes for separation-induced transition **Correction on $Re_{\theta,cr}$ when Hi>2.8**
- 4-equation transition model:
  - Transport critical value of $Re_{\theta,cr}$ $Re_{\theta,cr} = fn(Me, Hi)$
  - Integration/averaging of the Pohlhausen parameter Λ_2 following streamlines at BL edge
  - 2 x Integration of the curvilinear coordinate:
    - One for Λ_2 averaging
    - One for intermittency raising in the transition region

Relies on the evaluation of BL characteristics

Stability-Based Transition Model using Transport Equations

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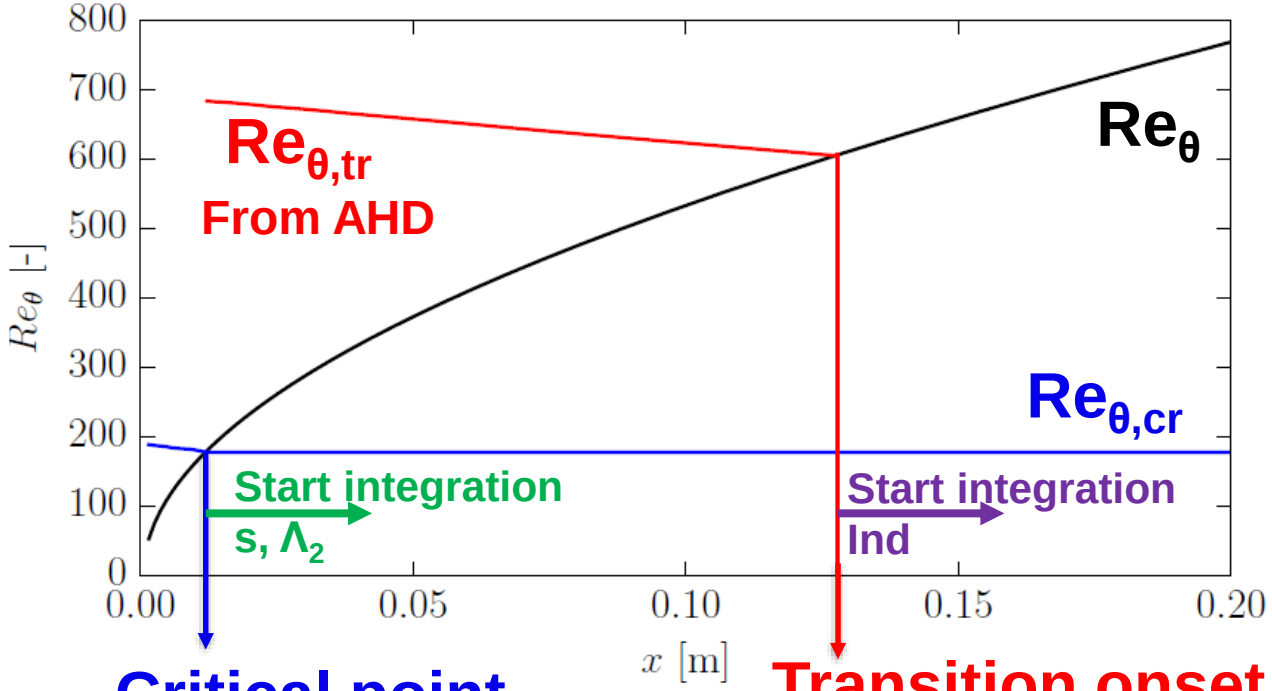
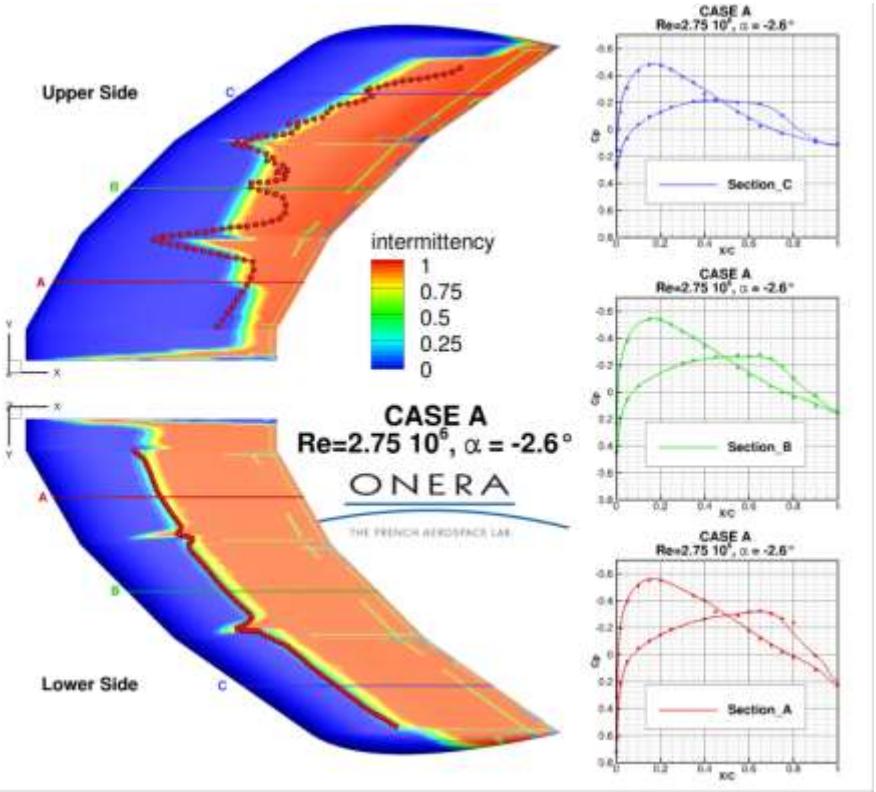
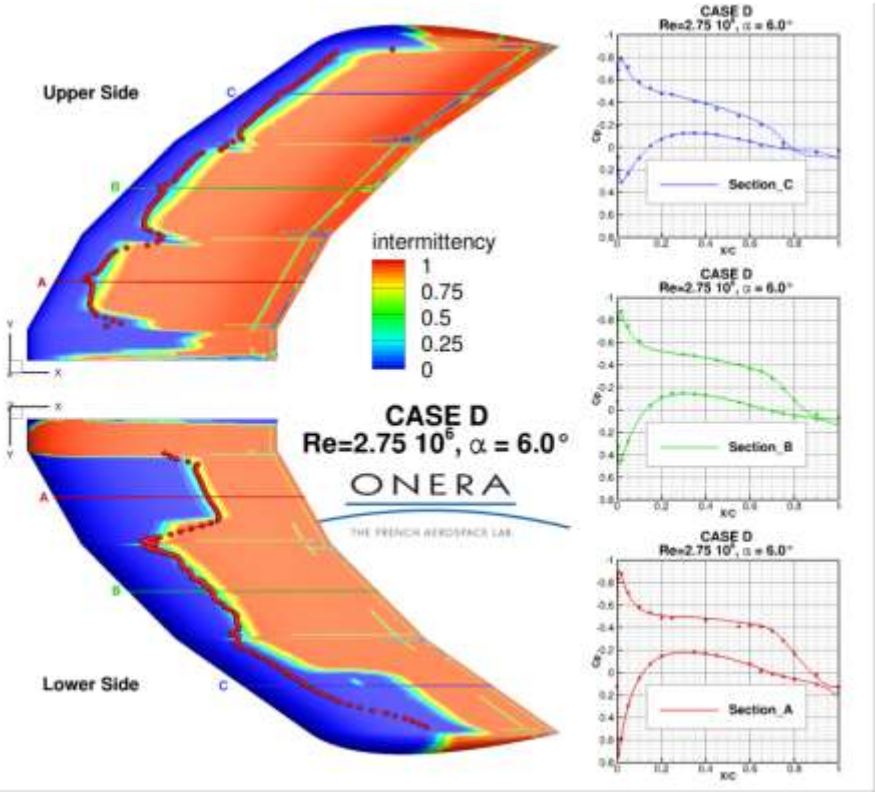
- Options
  - Local Λ_2 can be derived either
    - from wall pressure (incompressible)
    - → from BL edge velocity
  - Hi can be either
    - → computed from BL profile integration (needs fine mesh for accurate results)
    - from Λ_2 through correlation

Model behavior



Model behavior – Sickel Wing





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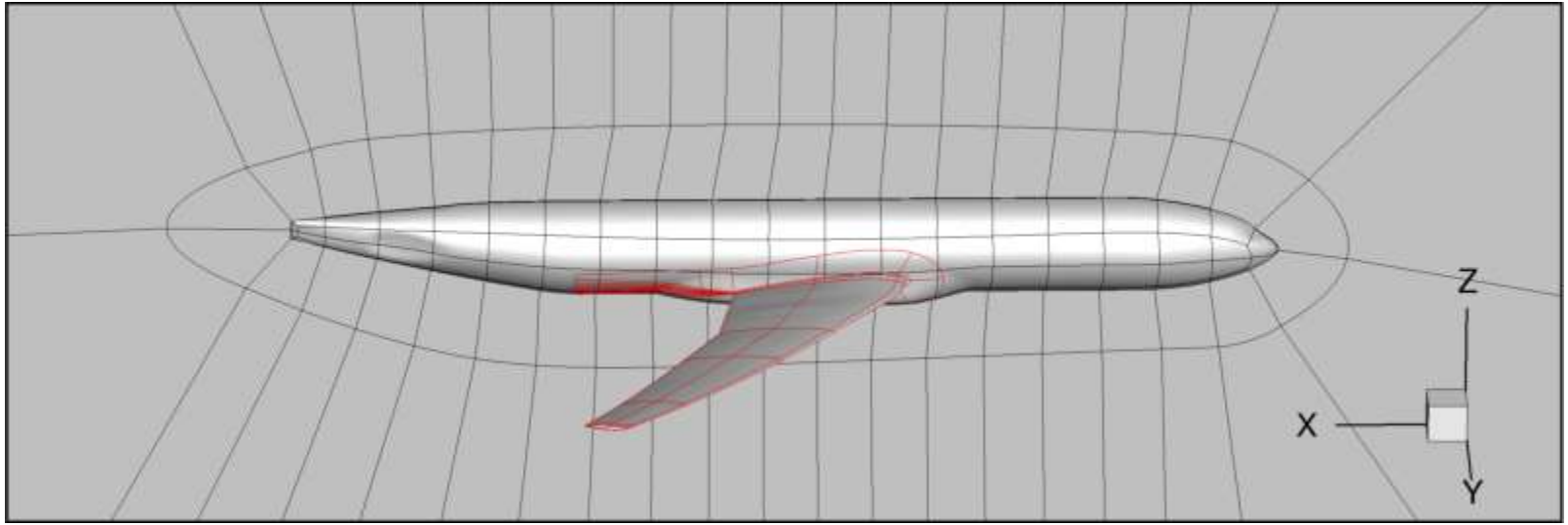
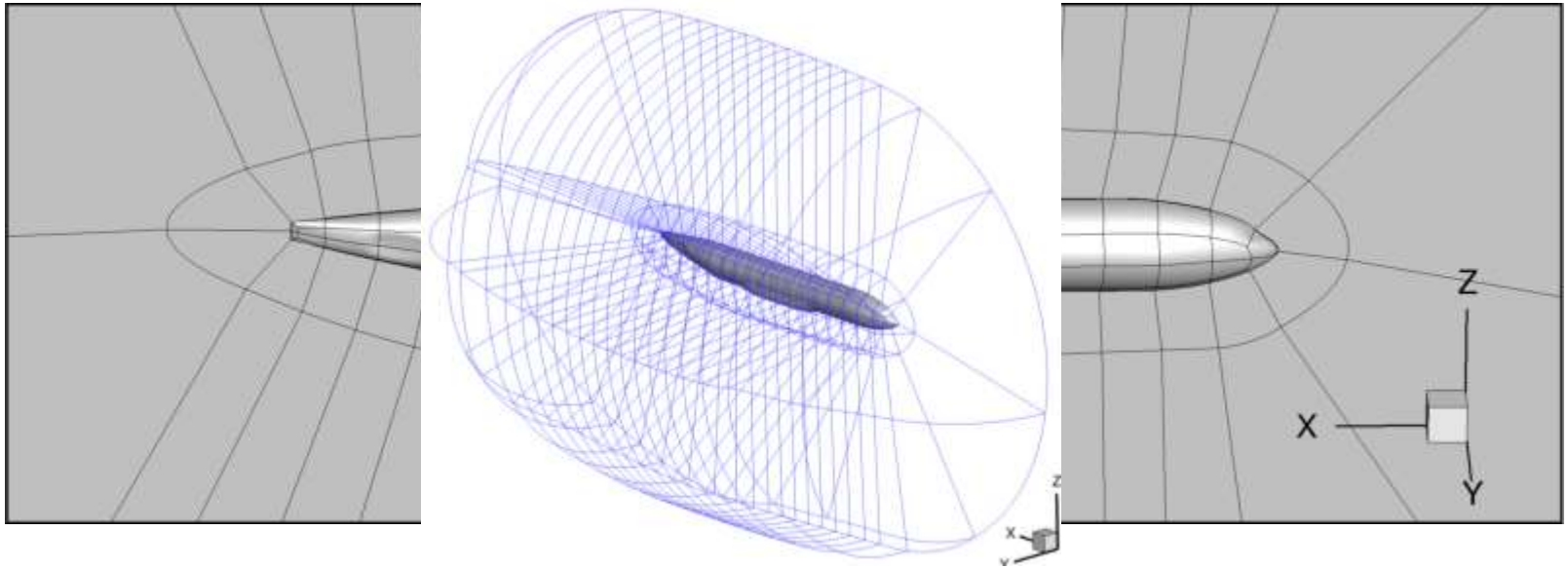
Grids

- Custom structured overset mesh



Grids

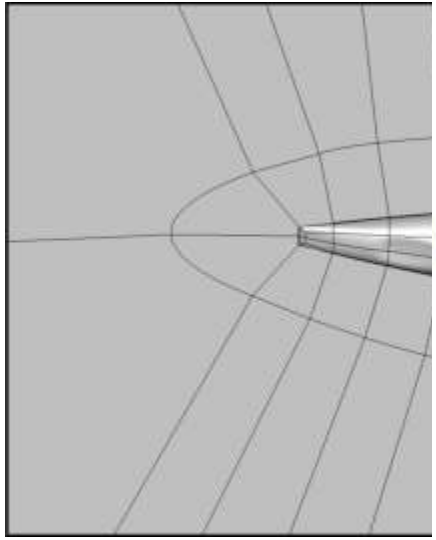
- Custom structured overset mesh

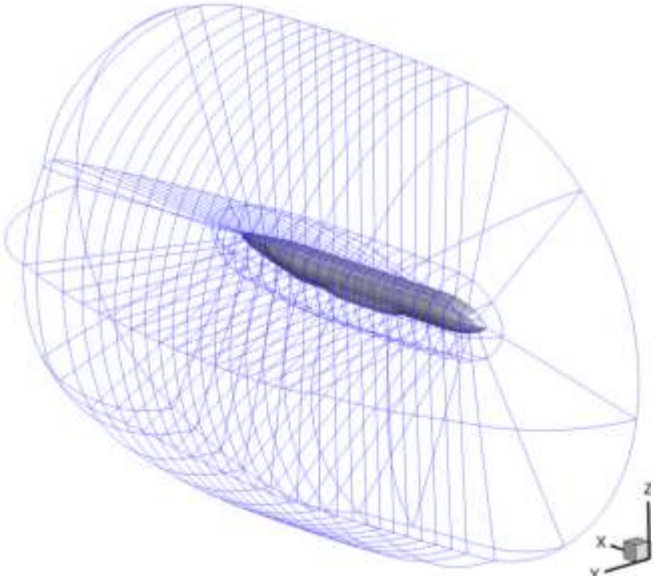


Fuselage nearbody

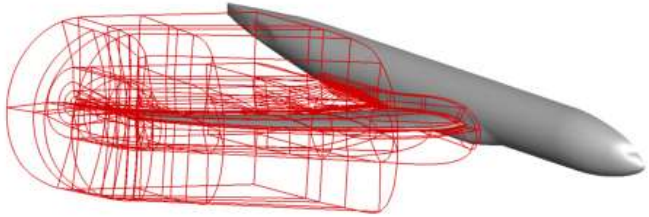
Grids

- Custom structured overset mesh





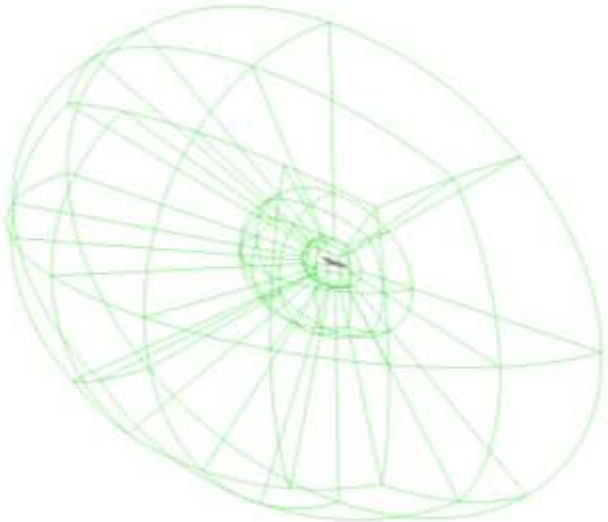
Fuselage nearbody

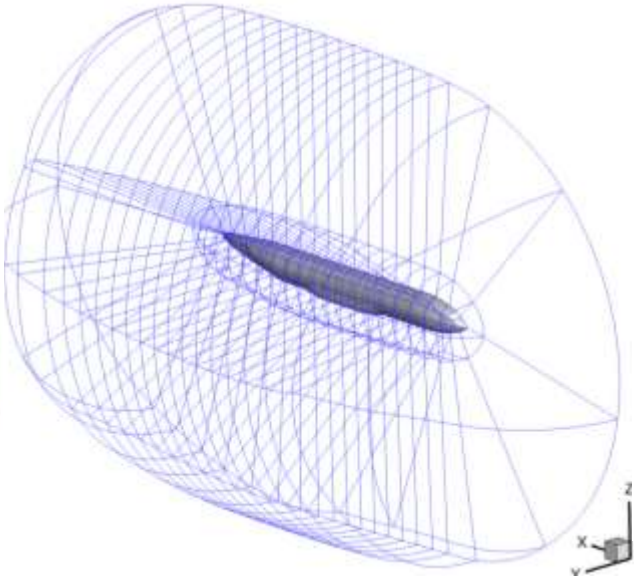


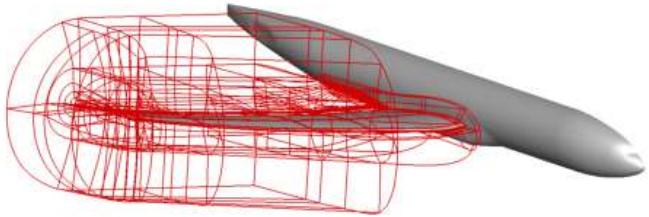
Wing C-mesh

Grids

- Custom structured overset mesh



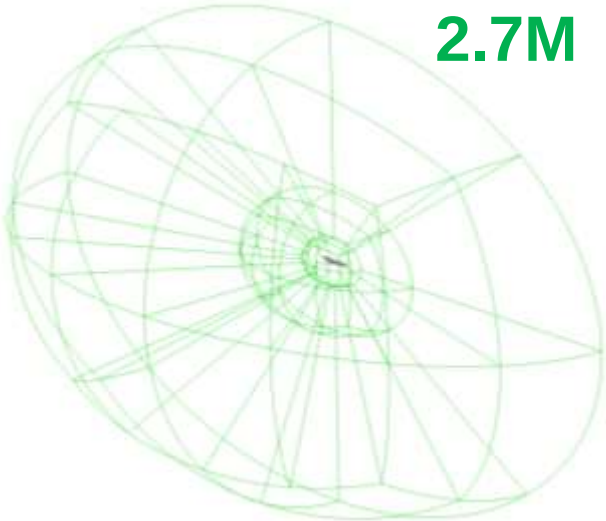




Background grid **Fuselage nearbody** **Wing C-mesh**

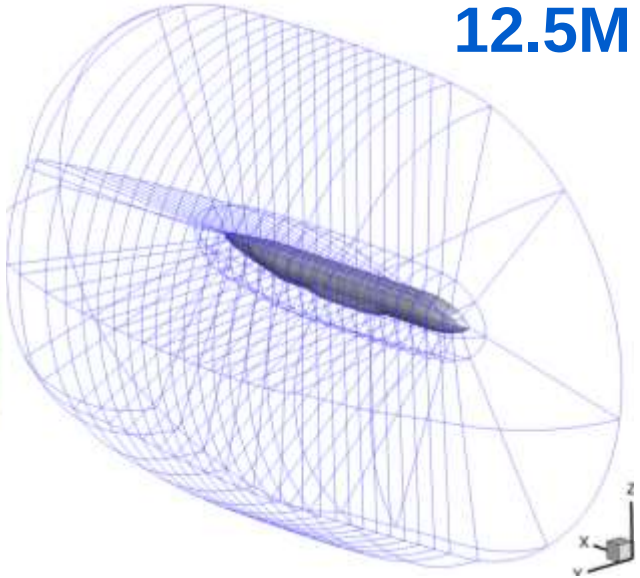
Grids

- Custom structured overset mesh (33.2M cells)



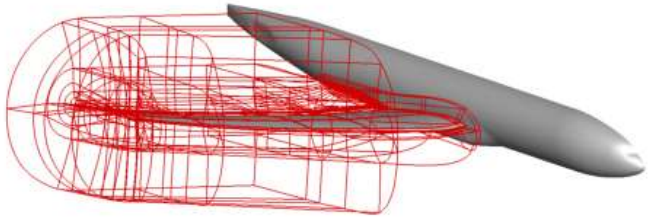
2.7M

Background grid



12.5M

Fuselage nearbody

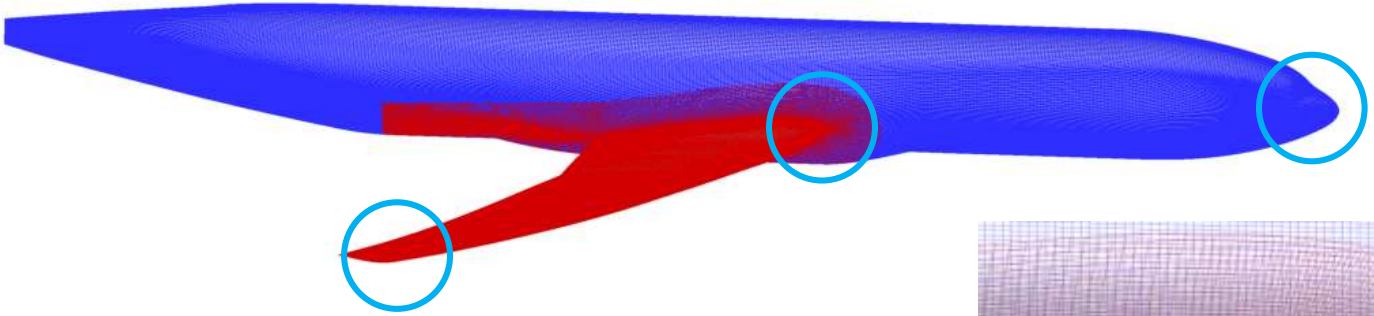


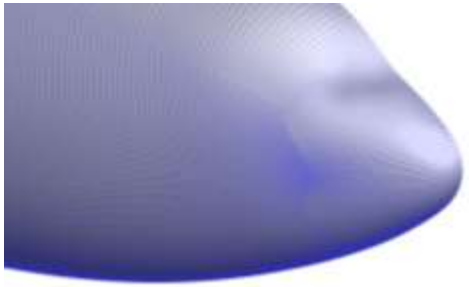
17.9M

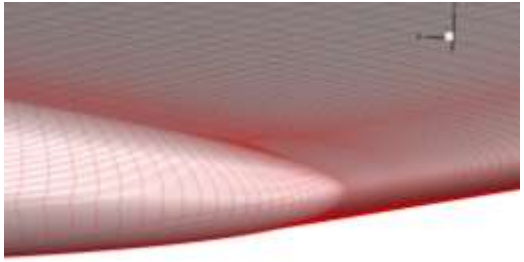
Wing C-mesh

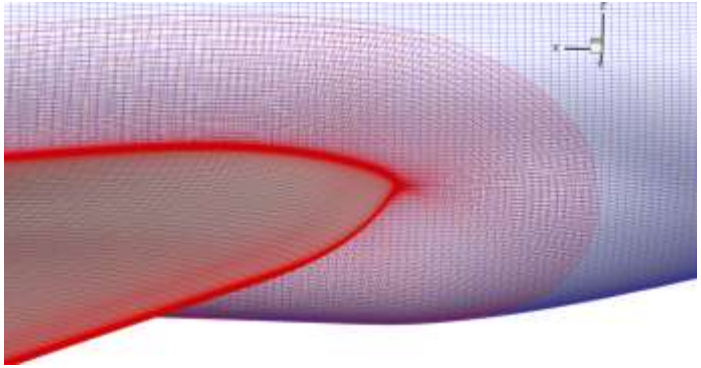
Grids

- Custom structured overset mesh (33.2M cells)
- y+ ~ 1/3, 40-60 cells in BL





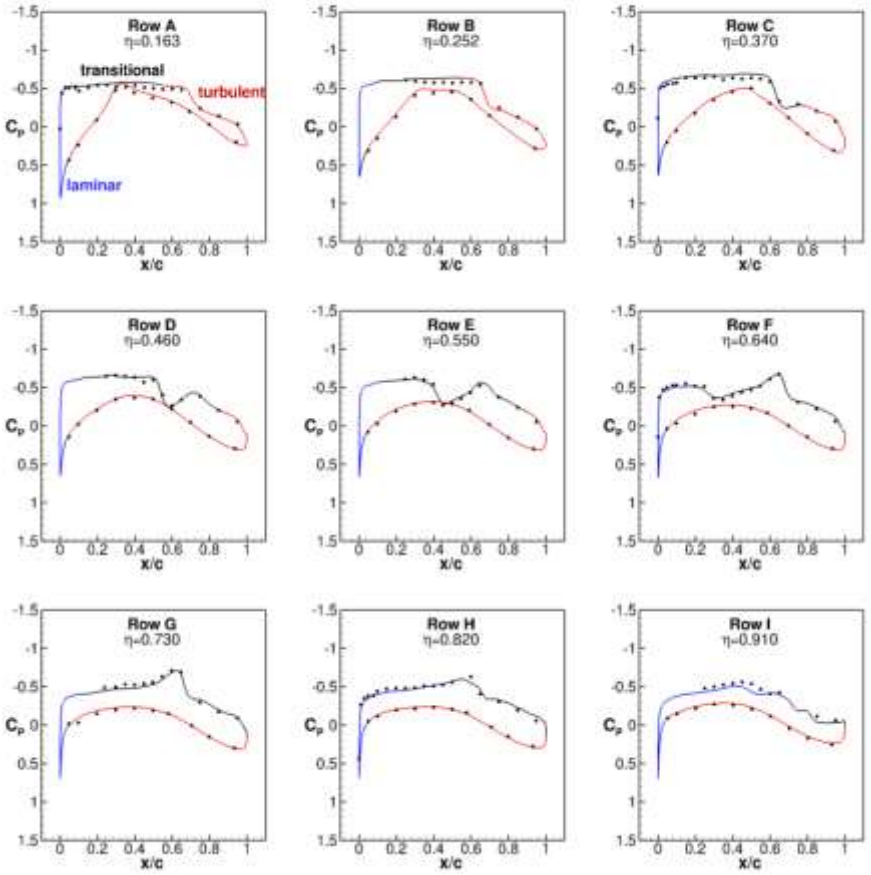


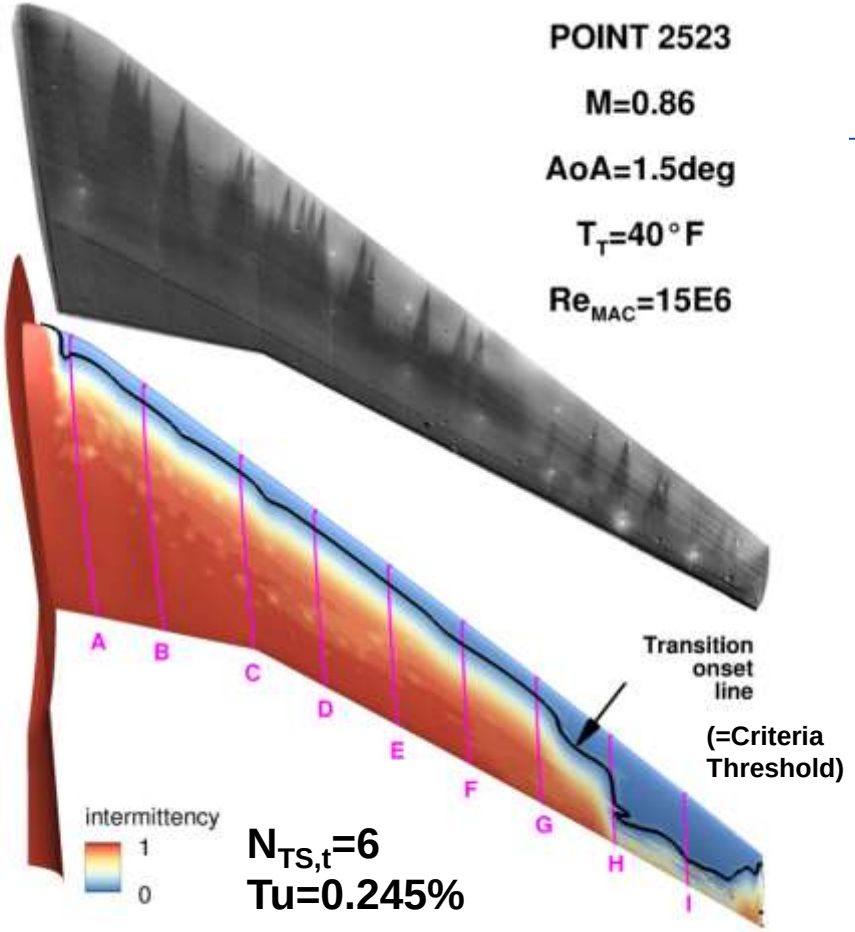


Outline

- Solver & models
- Grids
- **Pressure coefficient, transition lines**
- Force and moment data
- Perspectives

POINT 2523 M=0.86 AoA=1.5deg T_T=40°F Re_{MAC}=15E6





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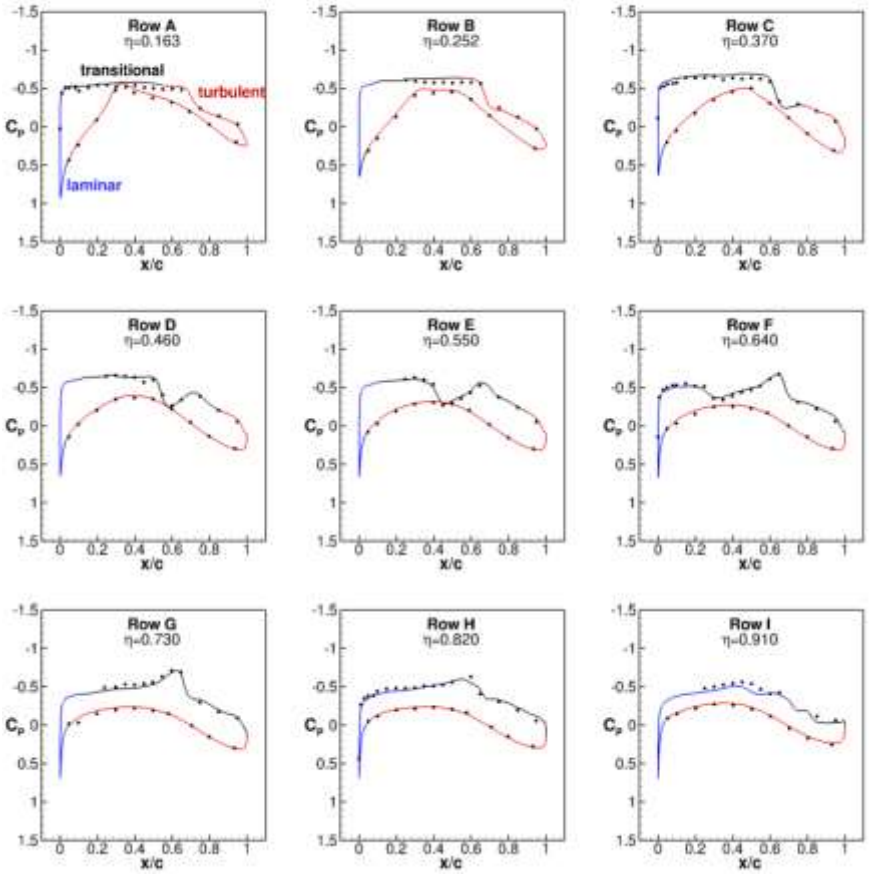
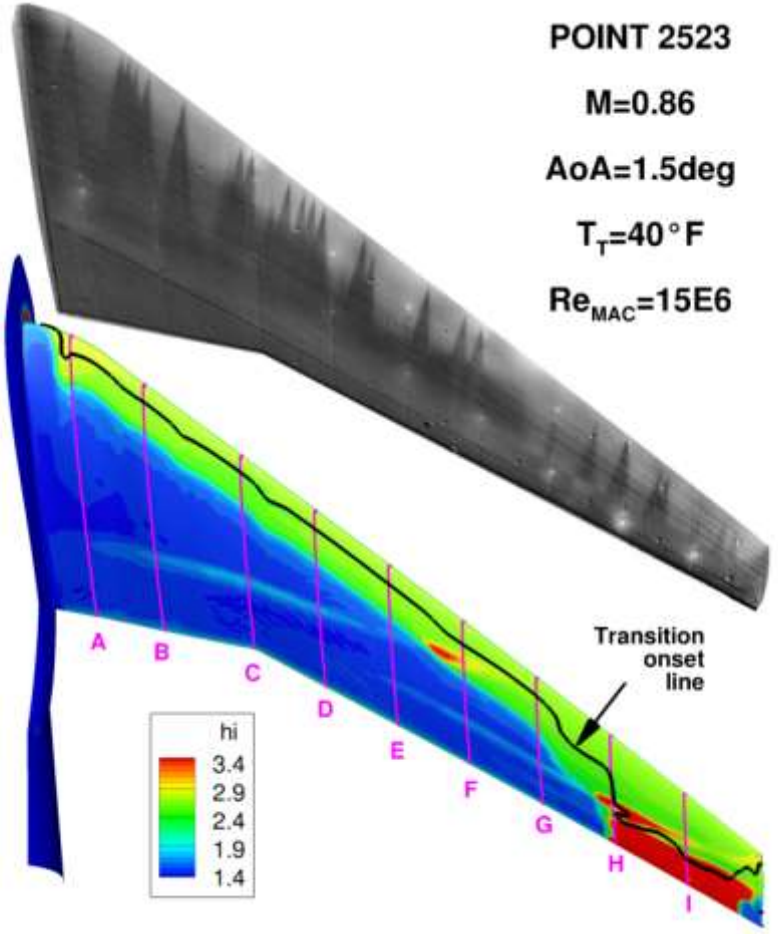
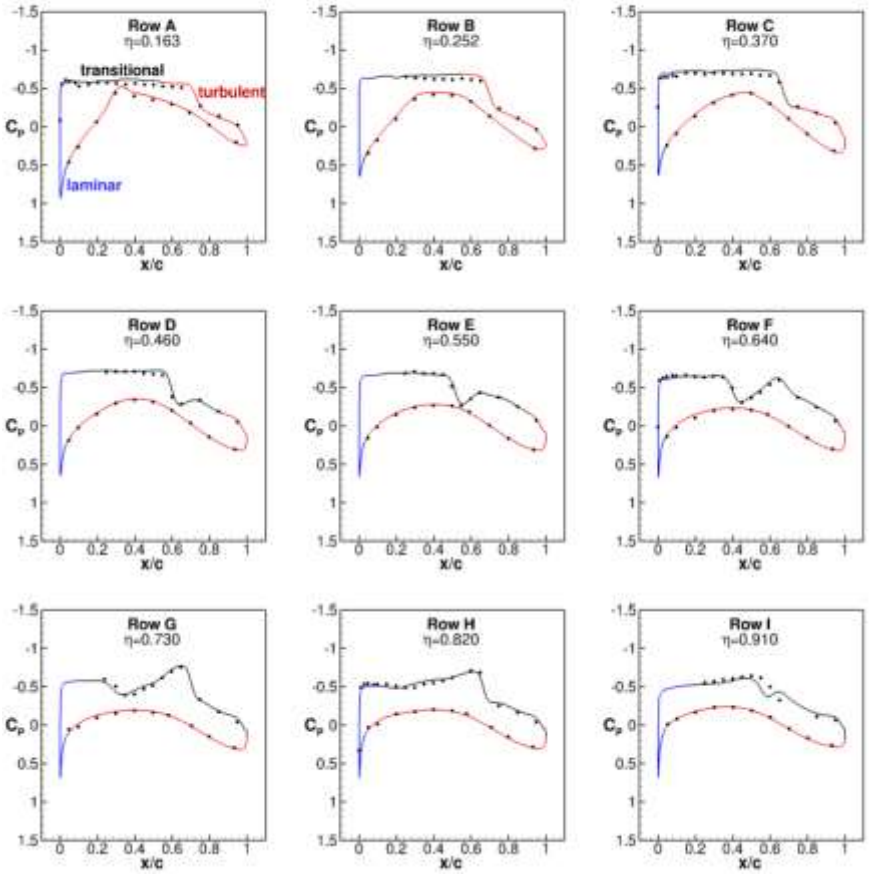
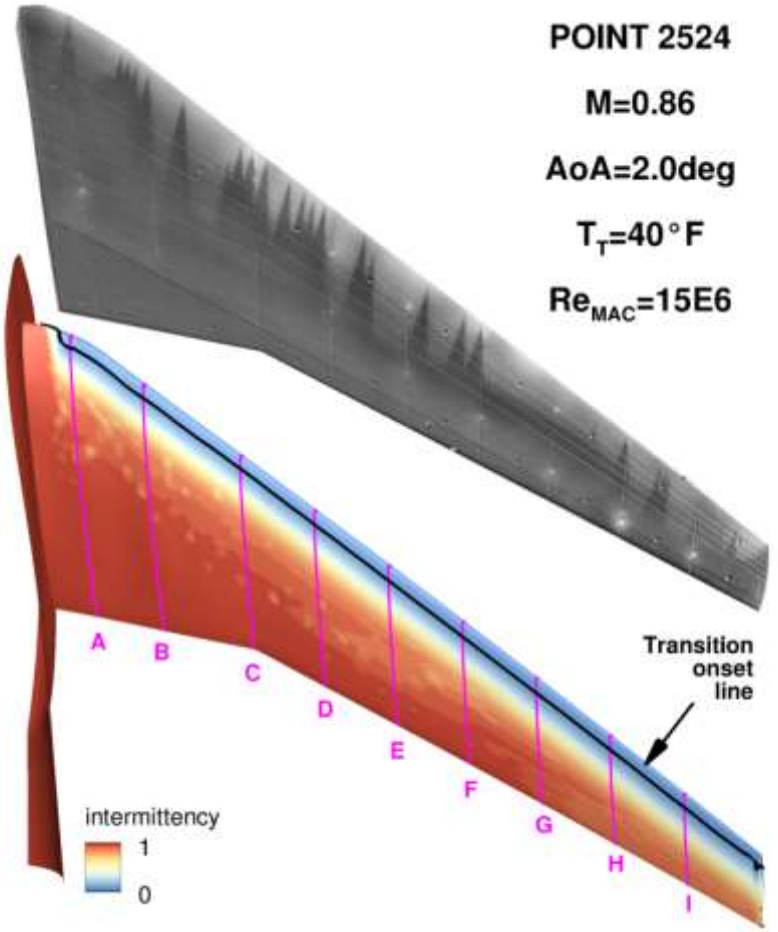




POINT 2524 M=0.86 AoA=2.0deg T_T=40°F Re_{MAC}=15E6





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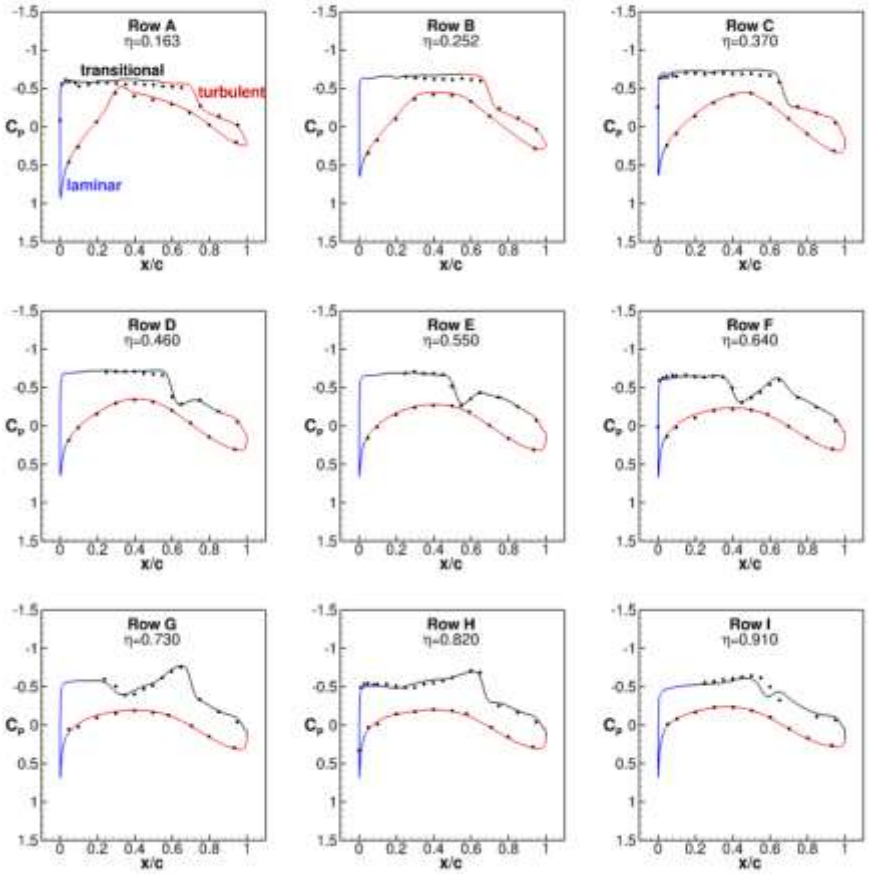

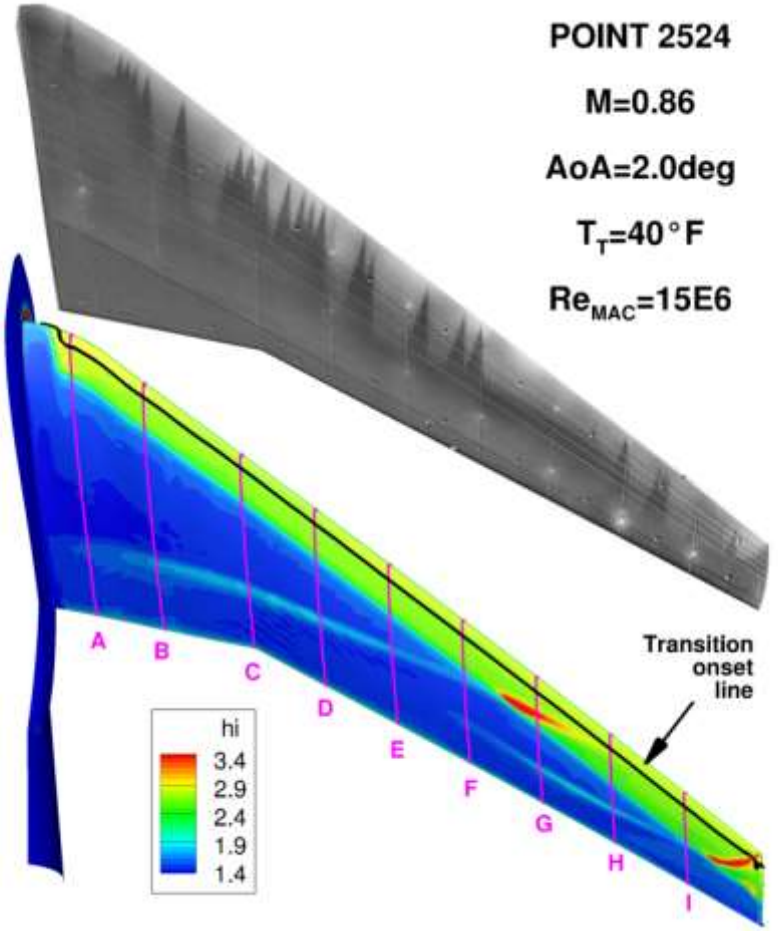

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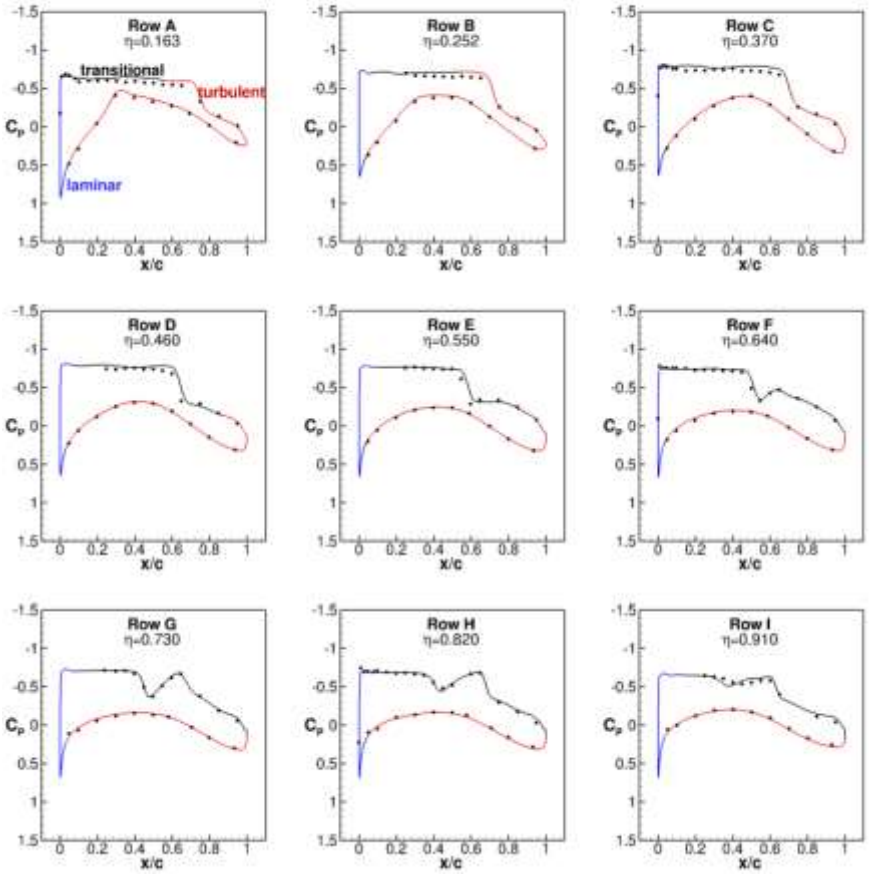

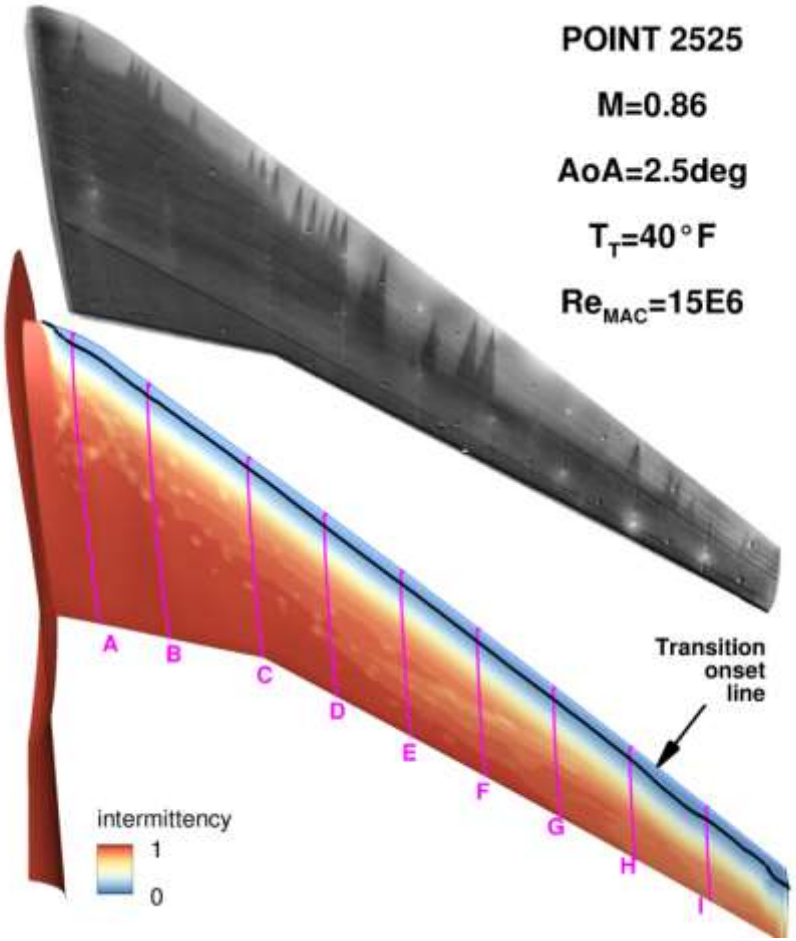

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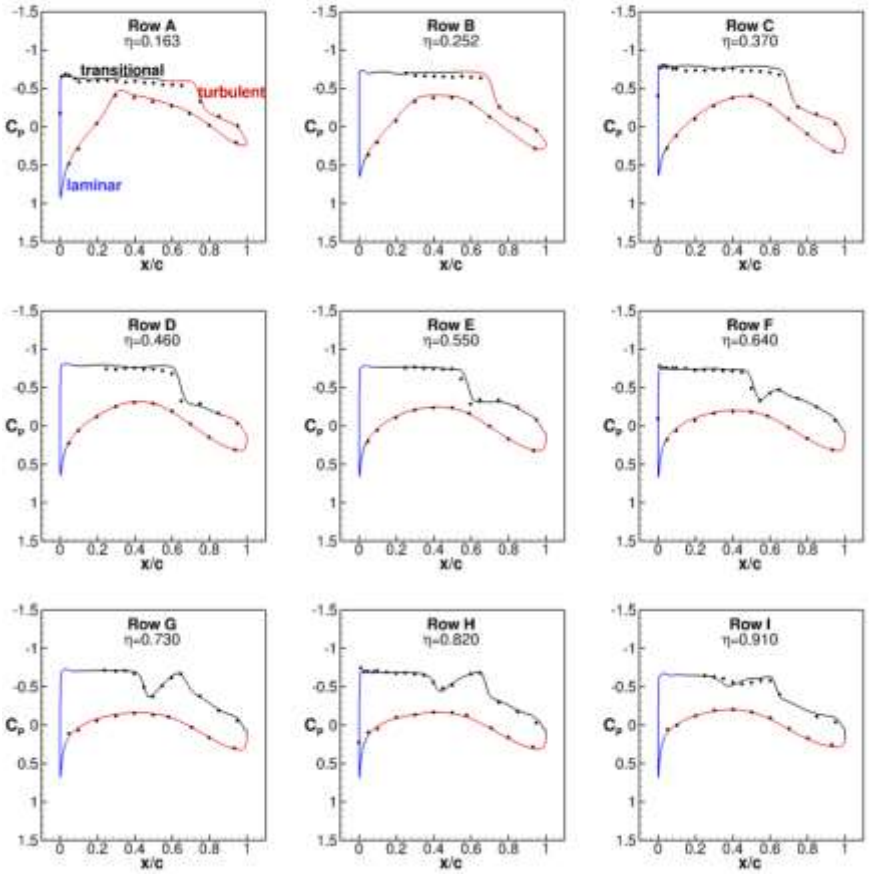
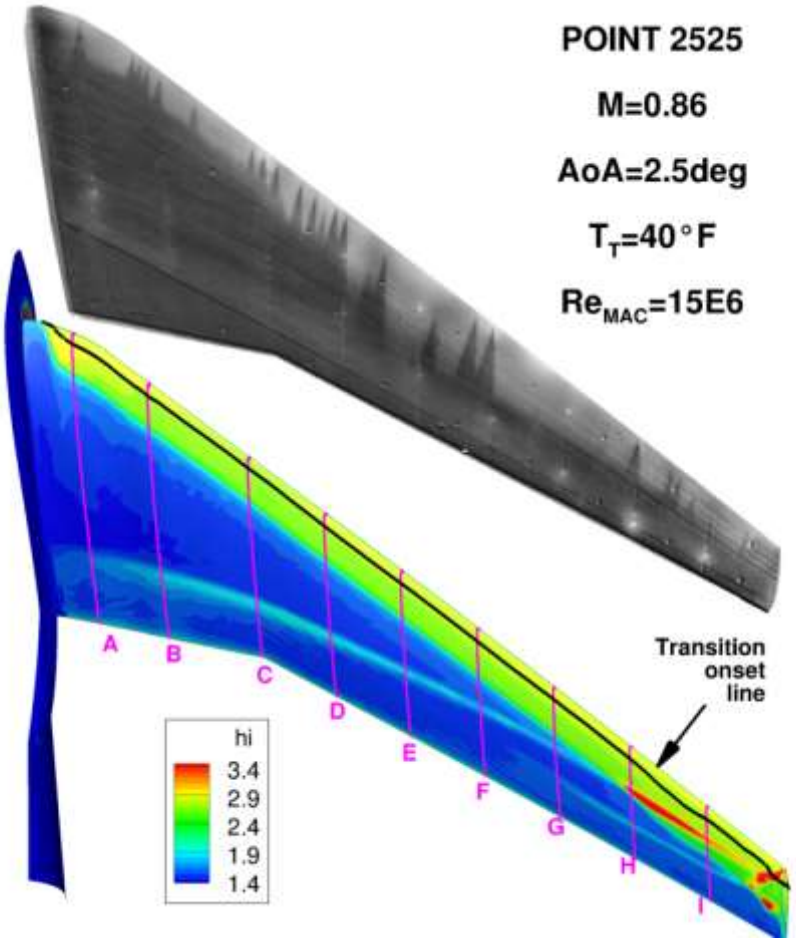
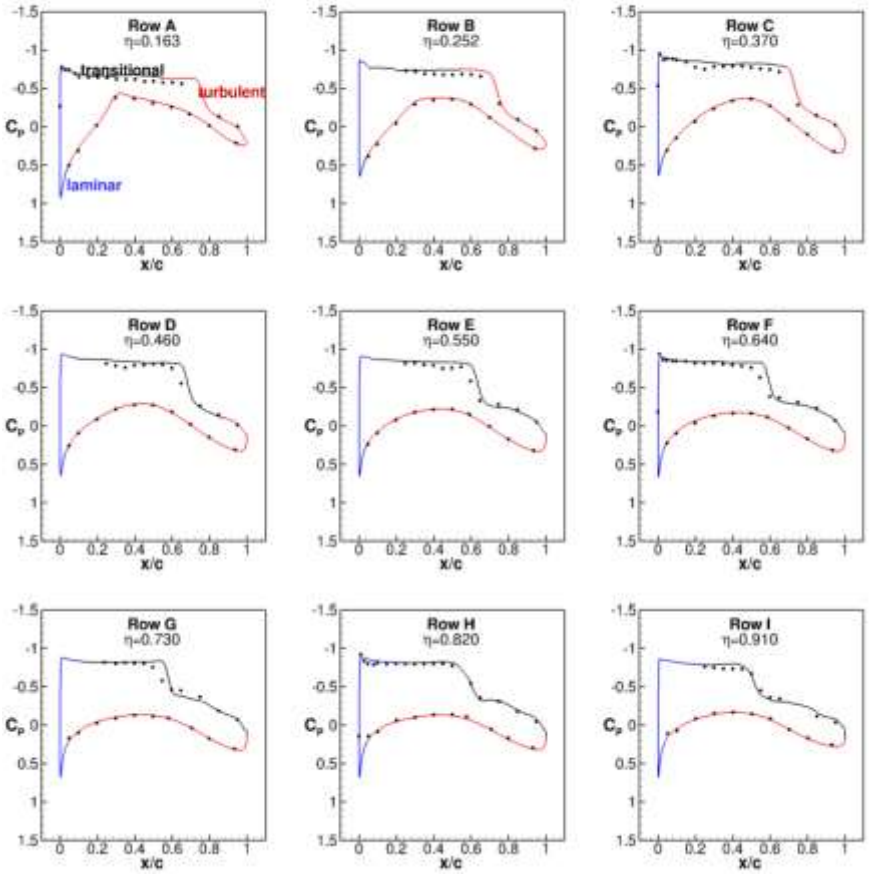
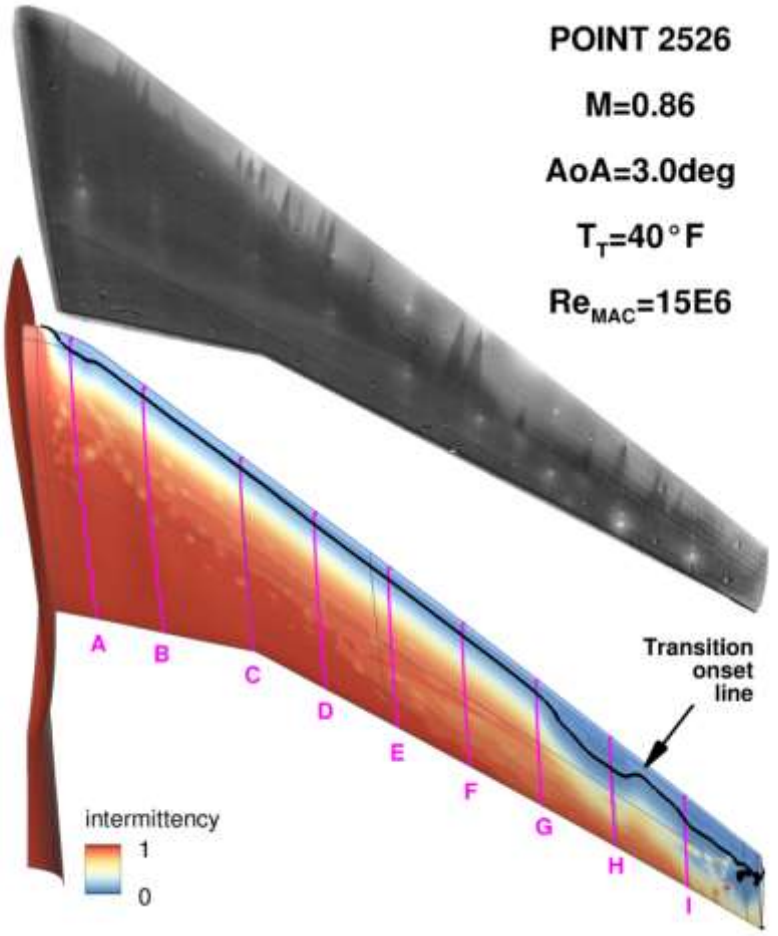




POINT 2526 M=0.86 AoA=3.0deg T_T=40°F Re_{MAC}=15E6





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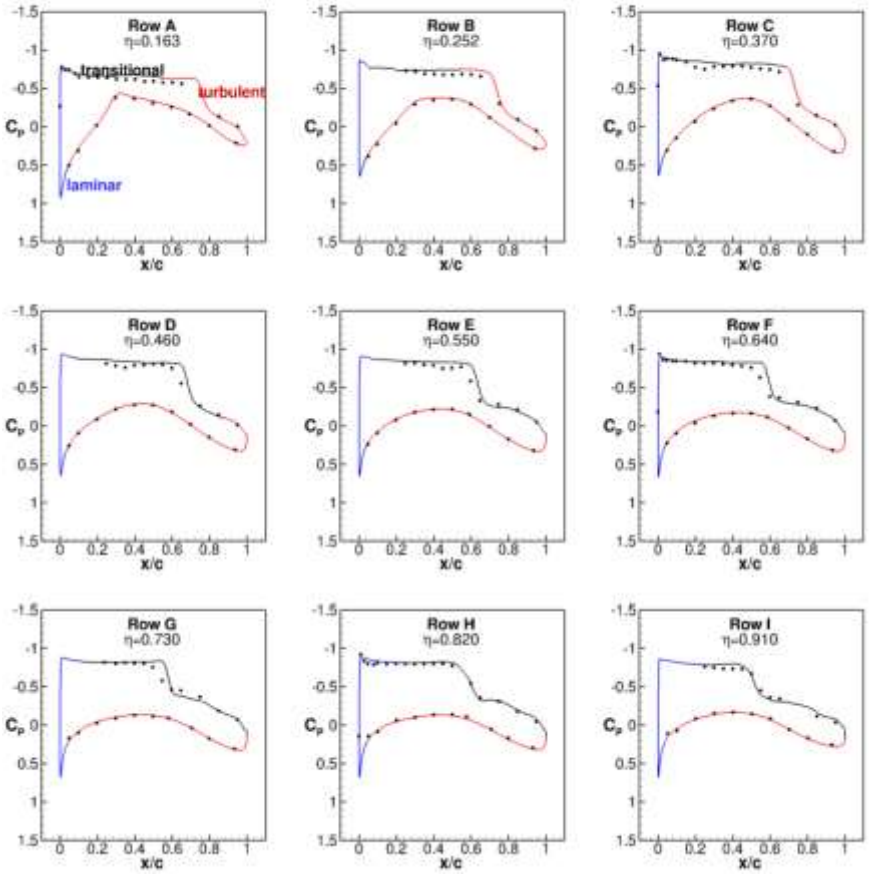
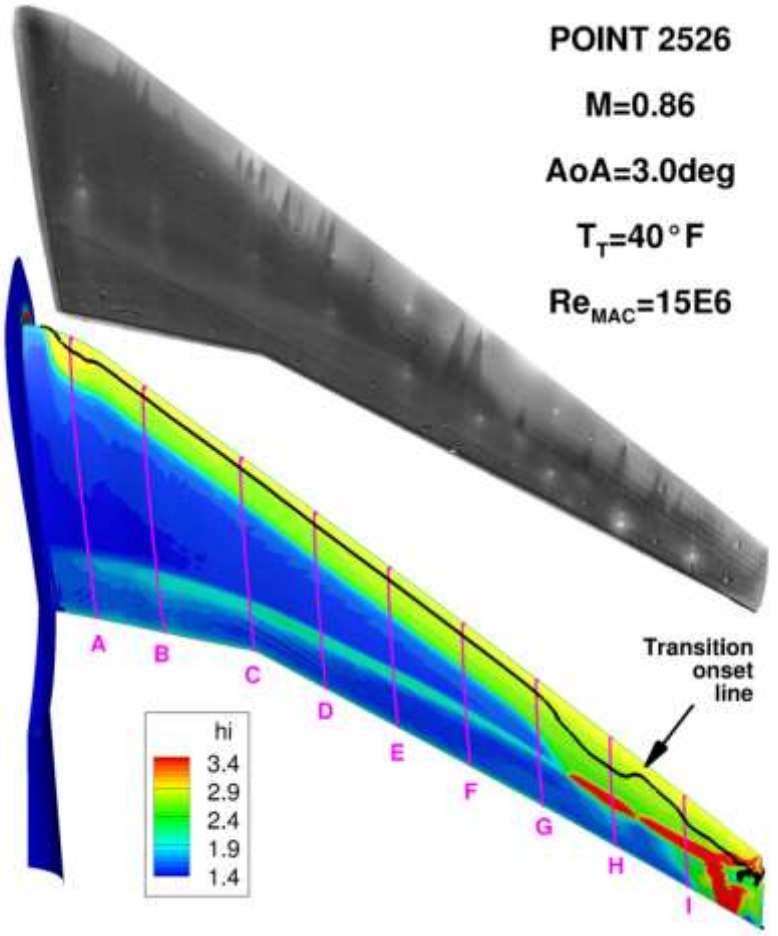
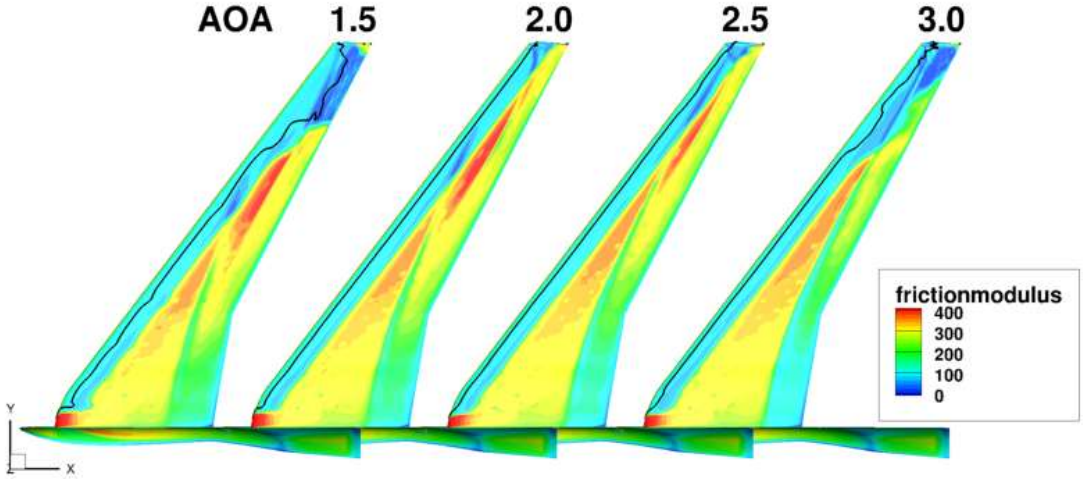




Observations on CFD results

- AoA 1.5: shock-induced transition in the outboard region in the CFD
- Early transition locations due to criteria threshold reached near the elading edge, fixed transition length in the CFD probably too short.



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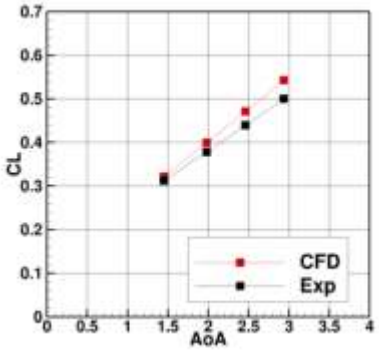
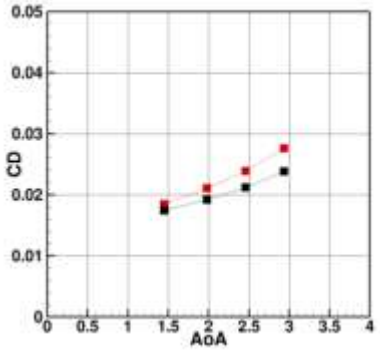
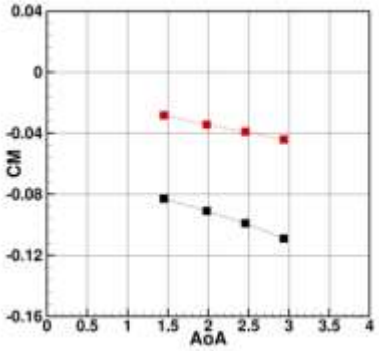
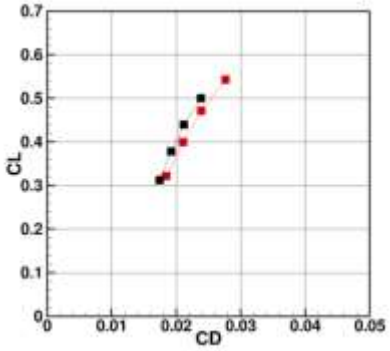
Force and moment data





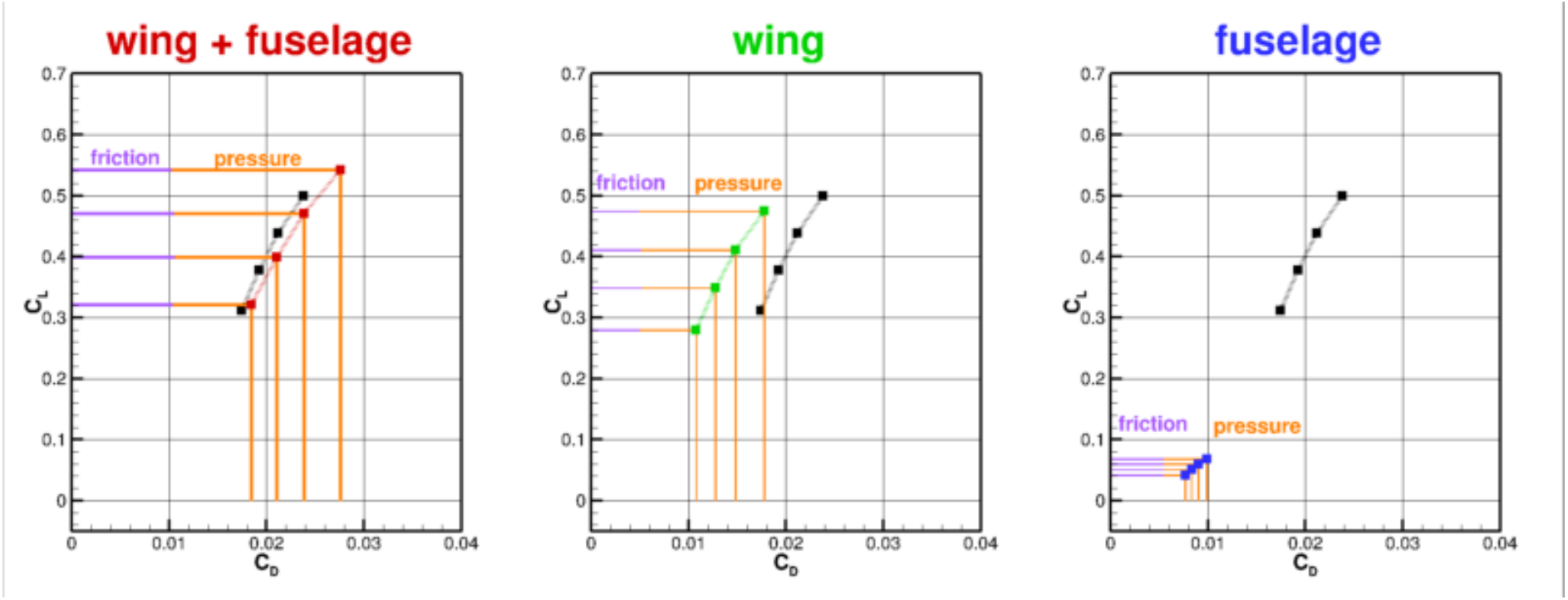




- Lift not too far from exp. values (recompression a little downstream of exp.)
- Drag overestimated (friction on wing)
- Pitching moment underestimated

  (Model Moment Center correct?)

Force breakdown



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Perspectives

- Investigate discrepancies on friction coefficient values (pressure side)

- Switch to new solver, ongoing validation for transition
- Will take a while, starting with simple test cases
- Grid convergence study in « full turbulent » on CRM-NLF using provided grids
  (Current mesh smoothed out most of Cp chordwise oscillations)